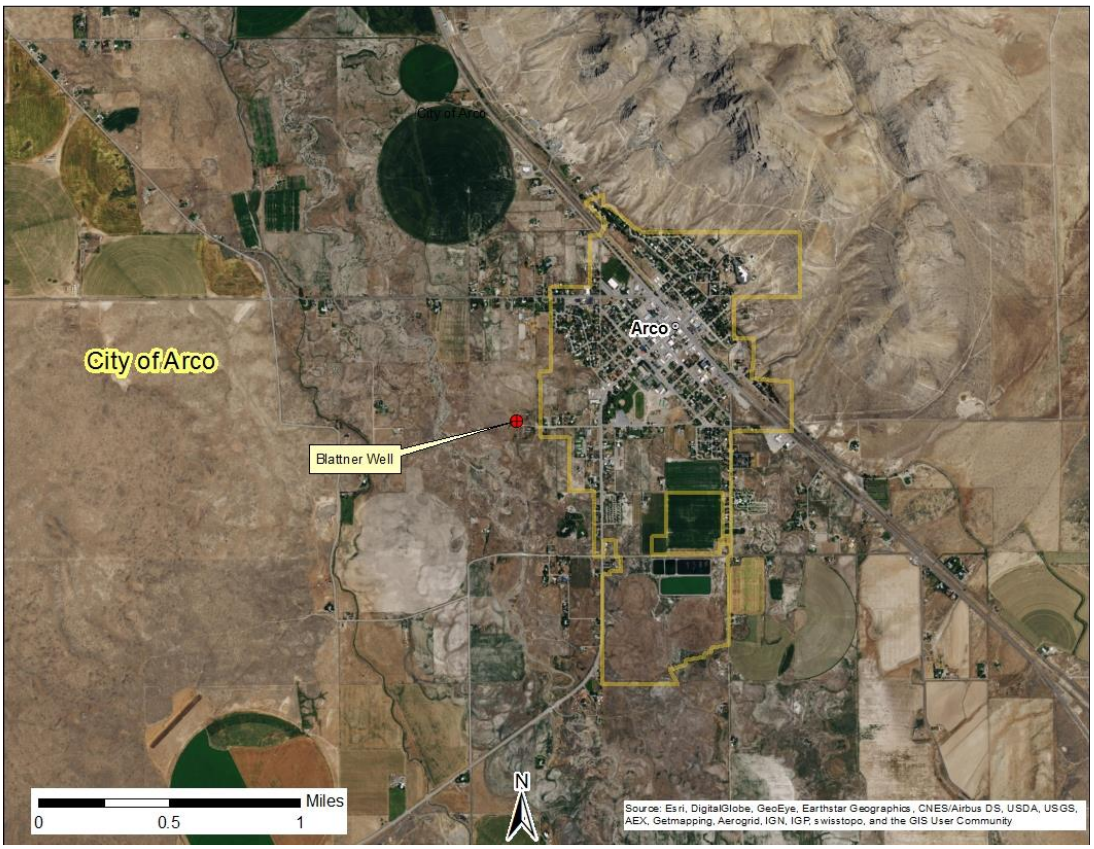
Source Water Delineation Modeling Report

City of Arco Blattner well (000000013501)

Public Water System #ID6120001



Idaho Department of Environmental Quality
Technical Services Division

November 2016

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1 Introduction

1.1 Background

In 1996, Congress amended the Safe Drinking Water Act (1974) to emphasize the protection of surface and ground water sources used for public drinking water. The amendments require that each state develop a Source Water Assessment Plan (SWAP) for public drinking water sources, conduct assessments of all public water systems (PWSs), and make the assessments available to the public. In Idaho, the SWAP was developed and is being implemented by the Idaho Department of Environmental Quality (DEQ).

The primary goal of Idaho's source water assessment (SWA) process is to develop information that enables PWS owners, operators, consumers, and others to initiate and/or promote actions to protect their drinking water sources. Each SWA involves three primary components:

1. Determining the area of contribution for each source (source area delineation),
2. Identifying potential sources of drinking water contamination within the area of contribution (contaminant source inventory), and
3. Determining the vulnerability of the water supply to potential contaminants identified during the inventory (susceptibility analysis).

In Idaho, ground water source areas are delineated using three different methods, depending on the availability of hydrogeologic data and whether the system is transient or non-transient. These are the arbitrary fixed-radius method, calculated fixed-radius method, and refined method. The arbitrary fixed-radius method is used for non-community transient systems and involves drawing a circle with a fixed radius of 1,000 feet around a well. The calculated fixed-radius method is based on simplified calculations of 3-, 6-, and 10-year time-of-travel (TOT) boundaries (i.e., capture zones) for Idaho's five generalized aquifer types. The radius for each TOT boundary is determined for each generalized aquifer type by referencing pumping rate tables presented in Appendix E of the Idaho SWAP (DEQ 1999). Finally, the refined method for determining 3-, 6-, and 10-year TOT boundaries involves computer modeling using site-specific data as input. The increased realism achieved by using site-specific data typically results in SWA areas that have less built-in conservatism and are often much smaller than those determined using the calculated fixed-radius method (DEQ 1999).

Assessment methods for ground water are important in Idaho because nearly 95% of the approximately 1,966 PWSs (DEQ 2016) rely on ground water as the source of their drinking water. These systems derive water from diverse and sometimes complex hydrogeologic settings.

This report summarizes the source area delineation work that was performed for the City of Arco Blattner well, PWS ID6120001. The Blattner well is located at the west edge of Arco, Idaho (Figure 1).

1.2 Purpose and Objectives

The purpose of this report is to present the results of source area delineation work that was performed the City of Arco Blattner well under the purview of the Idaho SWAP. Information from this report will be used to delineate a capture zone and develop a SWA report for the public drinking water source. Objectives of this report include the following:

1. Identify and describe the PWS in question.
2. Develop a conceptual model of the region's hydrogeology.
3. Based on the conceptual model, determine model input and perform capture zone delineations for 3-, 6-, and 10-year TOT.
4. Incorporate factors of safety into the final capture zones to account for model input uncertainty.

Local communities can use the information gathered through the assessment process to create a Source Water Protection program to address current problems and prevent future threats to the quality of their drinking water supplies.

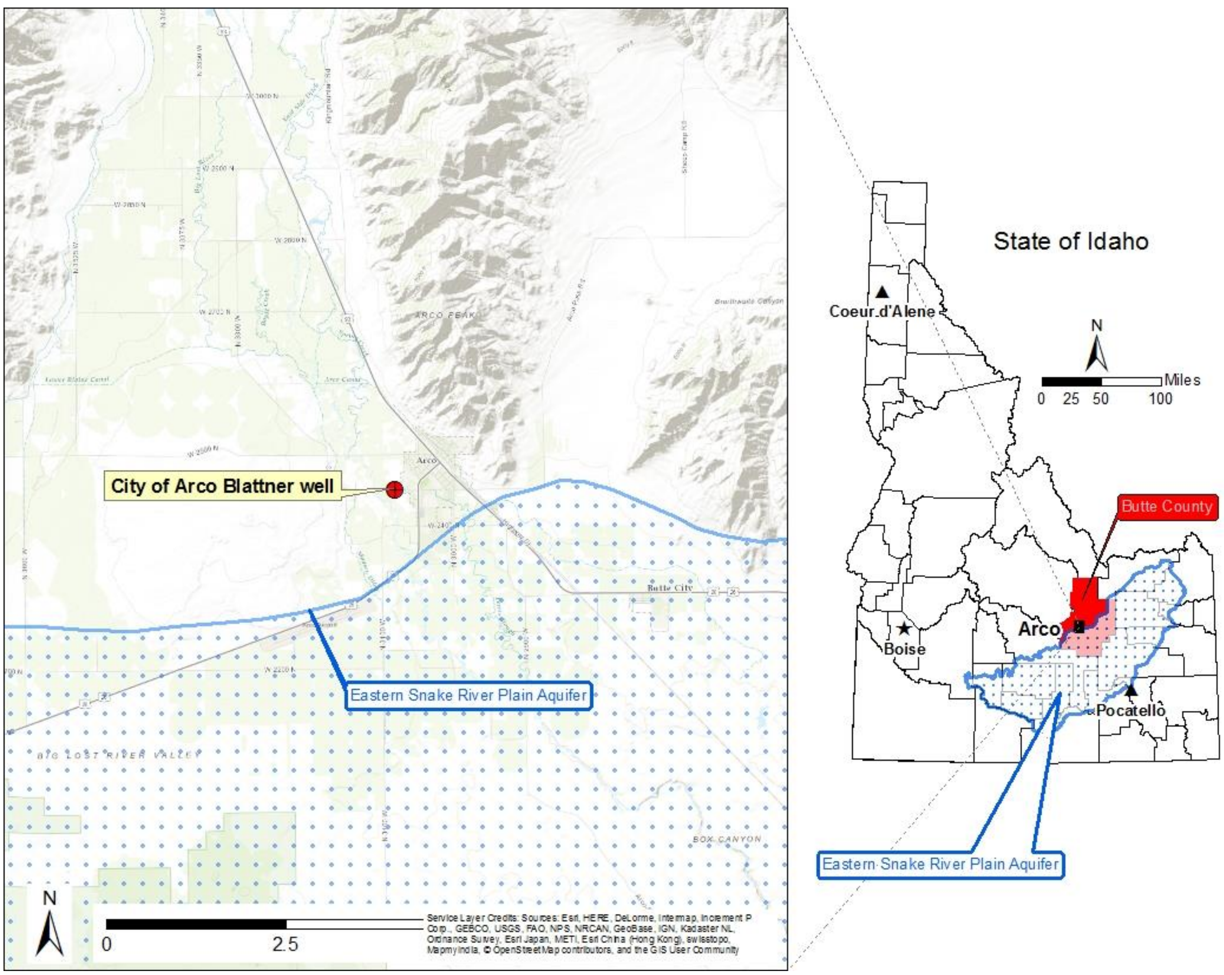

Figure 1. Site vicinity map of the City of Arco Blattner well.

1.3 Description of Public Water System

The City of Arco PWS is classified as a community public water system that serves a population of approximately 1,080 through 501 connections (DEQ 2016). Water is supplied to the system from two active wells. This report discusses the modeling information used to derive a capture zone for the Blattner well (tag # 000000013501).

The City of Arco Blattner well was completed on August 12, 2013 to a depth of 244 feet below ground surface (bgs), based on the driller's report (Appendix). The well was constructed with 16-inch diameter steel casing from three feet above ground surface to 203 feet bgs. A 14-inch diameter stainless steel screen was set from 203 to 239 feet bgs. The borehole is sealed from 70 to 40 feet bgs with bentonite grout and from 40 feet bgs to the ground surface with bentonite. The water-bearing formations are clean gravel and compacted cemented gravel. The static water level at the time of well completion was 114 feet bgs, which corresponds to an elevation of 5,208 feet above mean sea level (amsl). A copy of the driller's log is included in the Appendix.

1.4 Site Conceptual Model

The City of Arco is located near the southern end of the lower Big Lost River Valley, in Butte County, south central Idaho. The lower Big Lost River Valley extends from the confluence of Antelope Creek and the Big Lost River to a few miles south of Arco (Figure 2). The model boundary is where alluvium and colluvium pinch out and abut against the White Knob Mountains (chiefly undifferentiated sedimentary rock with lesser amounts of volcanic rock) on the west and the Lost River Range (chiefly sedimentary rock) on the east. Gravel and sand in the valley fill compose the main aquifers. The southern model boundary is approximately where Big Lost River valley fill intercalates with or abuts against basalt of the Snake River Group (Bassick and Jones 1992).

The alluvium of the primary aquifers is present in two forms; cemented and unconsolidated. A calcite cement binds together fragments of sandstone, quartzite and limestone of the old alluvial fans. The unconsolidated materials are composed of clay to boulder size particles and, in places, range greatly in the degree of sorting (Szczepanowski 1982).

Crosthwaite et al. (1970) report that well yields of 2,000 to 3,000 gallons per minute are common for irrigation wells in the Arco area. The yield per foot of drawdown varies widely, however, depending on the type of alluvium and the lateral extensiveness of the water-bearing unit. The greatest drawdowns observed in the valley occur in wells southwest of Arco (Crosthwaite et al. 1970). Hydraulic conductivity estimates for the unconsolidated alluvium range from approximately 75 to 3,000 gallons per day per square foot (DEQ 1997, Table F-3).

Regional ground water flow is to the south, parallel to the valley axis (Bassick and Jones 1992). Reported water table gradients along the valley axis range from 10 to 100 feet per mile (ft/mile) and average 23 ft/mile or 0.0043 ft/ft (Crosthwaite et al. 1970). The effective porosity is estimated to be 0.3 for alluvial systems in the Arco area (WGI 2001).

Precipitation on the valley floor and stream channel losses are the two other primary sources of recharge to the ground-water reservoir (Szczepanowski 1982). Mean annual precipitation in the Arco area is 11 inches per year (in/y) (PRISM 2012), as interpreted from available geographical information system (GIS) data. Seasonal water table fluctuations in excess of 40 feet have been recorded in response to irrigation seepage and canal leakage (Crosthwaite et al. 1970).

Natural discharge of ground water occurs into gaining reaches of the Big Lost River, as spring discharge, as ground water leaving the basin south of Arco, and as evapotranspiration where the water table is at or near the land surface. Ground water is also artificially discharged through pumping wells (Szczepanowski 1982).

2 Ground Water Flow Model

2.1 Method

The capture zones for the source wells are delineated using WhAEM 2000 software, version 3.2.1 (EPA 2007). WhAEM is a single-layer steady-state ground water flow model using the analytical element method to determine the ground water flow regime (Thorbjarnarson 2001). Various hydraulic features may be represented by a combination of inhomogeneity, well, and linesink elements; such as streams, well fields, lakes, and areal recharge (Thorbjarnarson 2001).

DEQ's interpretation of the geology, hydrogeology, and aquifer properties of the Arco area is based on a compilation of selected literature and area well driller's reports. The capture zone derived from this modeling effort should be viewed as a best estimate, based on available information from published studies, well logs, and research of previous modeling efforts. If more data become available the delineations may be updated with the new information.

2.1.1 Test Points

Test point well data were obtained from the IDWR (2016) well construction database and from the United States Geologic Survey's National Water Information System (NWIS): web interface (USGS 2016). Available data were reviewed to identify ground water wells near the City of Arco wells completed in the valley fill alluvium near the same elevation. These wells are assumed to produce from the same zone and to be hydraulically connected to the well. Water level information was obtained directly from well drillers' reports or the USGS database (2016). The reported water levels can have a wide range depending on the time of year that they were measured, as the water levels often vary 20 feet within a single well over the course of the year, with the highest water levels typically measured in the fall and lowest water levels measured in the spring (Crosthwaite et al 1970). The water levels reported for test points used in the model range from 98 to 160 feet bgs (Table 1).

The location and elevation of test point wells was acquired from the well driller's reports generally reported in the Public Land Survey System (PLSS); which is reputedly accurate to a quarter-quarter section. Therefore, the accuracy of elevation input is relative to surface elevation variability in addition to individual well activity and accuracy of measurement methods. The errors associated with measuring point elevations are as great as ± 20 feet. The test points used in this model are summarized in Table 1 and displayed in Figure 2.

Table 1. Test point data summary.

Test Point	Measurement Date	Well Completion	Measuring Point Elevation (ft amsl)	Depth to Water (ft bgs)	Water Level (ft amsl)
1	6/21/1994	Alluvium	5,335	120	5,215
2	8/12/2013	Alluvium	5,322	114	5,208
3	3/10/1993	Alluvium	5,344	120	5,224
4	6/24/2003	Alluvium	5,387	140	5,247
5	9/20/2014	Alluvium	5,354	108	5,246
6	8/16/2001	Alluvium	5,404	113	5,291
7	7/29/2004	Alluvium	5,394	111	5,283
8	12/9/2002	Alluvium	5,430	138	5,292
9	8/30/2004	Alluvium	5,449	115	5,334
10	5/12/2005	Alluvium	5,459	98	5,361
11	8/8/1992	Alluvium	5,530	132	5,398
12	6/16/2004	Alluvium	5,572	140	5,432
13	9/14/2001	Alluvium	5,613	160	5,453

Notes: ft amsl = feet above mean sea level; ft bgs = feet below ground surface

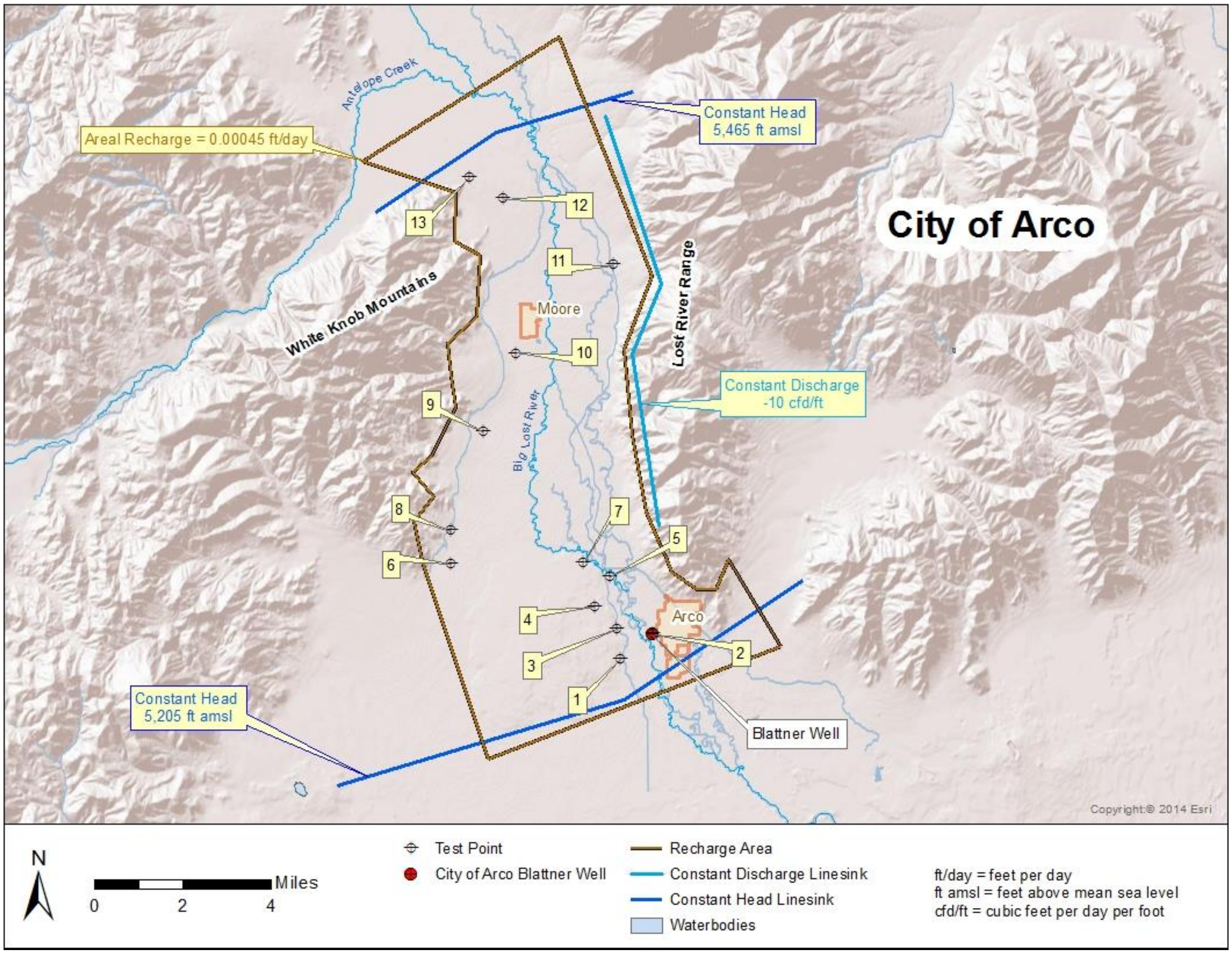

Figure 2. City of Arco model setup illustrating location of test points, pumping well, linesink elements, and recharge area.

2.1.2 Boundary Conditions

The boundary conditions outlined below represent the best-fit inputs used to develop the final delineation product (Figure 2). The linesink and inhomogeneity model elements used to develop this aquifer delineation are provided in Table 2.

Two constant head linesinks and a constant discharge linesink were placed in the model to establish initial steady-state conditions. One constant head linesink element was placed north of Moore (5,465 feet amsl) and one constant head linesink element was placed south of Arco (5,205 feet amsl) to establish water table elevation and gradient based on published water table contour maps and previous source water delineation reports for the Big Lost River Valley (Crosthwaite et al. 1970 and WGI 2001). The constant discharge linesink element was added along the base of the mountain range east of the Big Lost River Valley to represent recharge from the Lost River Range to the valley alluvium. The constant discharge value of -10 cubic feet per day per foot is based on a value presented by WGI (2001).

2.1.3 Base Elevation

The base elevation (bottom of the aquifer) was assigned a value of 5,086 ft amsl, based on the lowest approximate elevation of the open interval for the City of Arco Blattner well (IDWR 2016).

Table 2. Big Lost River Valley aquifer model elements.

Model Elements	Description	Value in Model	Units
Constant Head	North of Moore	5,465	ft amsl
Constant Head	South of Arco	5,205	ft amsl
Constant Discharge	Along east edge of Big Lost River Valley	-10	cfd/ft
Recharge	Areal Recharge	0.00045	ft/d

Notes: ft amsl = feet above mean sea level; cfd/ft = cubic feet per day per foot; ft/d = feet per day

2.1.4 Areal Recharge

Mean annual precipitation in the Big Lost River valley near Arco is approximately 11 in/y (PRISM 2012). Based on the Crosthwaite et al. (1970) observation that nearly all the precipitation falling on irrigated land in the Big Lost River valley is lost by evapotranspiration, area recharge was estimated to be only approximately 2 in/y (0.00045 ft/day).

2.1.5 Aquifer Thickness

The aquifer thickness used in the model was 40 feet. This value is the thickness of the water-producing gravel unit within the City of Arco Blattner well.

2.1.6 Hydraulic Conductivity

Hydraulic conductivities reported for the Arco area are widely variable as wells produce from at least five different water-bearing zones (Crosthwaite et al. 1970). The area is highly heterogeneous with sand and gravel and localized clay lenses overlying basalt bedrock (WGI 2001). All of these lithologies are present in the Blattner well; however, the water bearing unit in which the well is completed is described as clean gravel. Hydraulic conductivity values for clean gravel typically range from 1,000 to 1,000,000 ft/d (Freeze and Cherry 1979). However, transmissivity calculations using Bradbury and Rothschild (1985) and available information from the well driller's report for the Blattner test well resulted in a hydraulic conductivity for the gravel aquifer of only 50 ft/d. A possible explanation for this very low value may be due to the presence of widely scattered lenses of low permeability materials within the basin (Szczepanowski 1982). The value used in the model was 400 ft/d, which calibrated with the smallest residuals and is about mid-way between the published minimum values and the value estimated with pump test data from the Blattner test well.

2.1.7 Porosity

The effective porosity is 0.30. This is the default value presented in Table F-3 of the *Idaho Wellhead Protection Plan* for unconsolidated alluvium, which is considered to be most representative of the alluvium in which the Blattner well is completed (DEQ 1997).

2.1.8 Modeled Well

The pumping rate for the City of Arco Blattner well was based on data provided by the system operator. The average daily production of Blattner well is reported to be 224,500 gallons per day (30,000 cf/d). The parameters used to develop the model are summarized in Table 3. The sanitary setback of all PWS wells is 50 feet (DEQ 1999).

Table 3. City of Arco well model parameters.

City of Arco PWS	Modeled Base Elevation (ft amsl)	Casing Radius (feet)	Modeled Aquifer Thickness (feet)	Modeled Hydraulic Conductivity (ft/d)	Modeled Porosity	Modeled Discharge (cf/d)
Blattner well	5,086	0.67	40	400	0.30	30,000

Notes: PWS = public water system; ft amsl = feet above mean sea level; ft/d = feet per day; cf/d = cubic feet per day

2.2 Calibration

The model was calibrated by comparing the reported head values to modeled head values at test point locations. Modeled aquifer parameters and boundary conditions were adjusted manually until a reasonable fit occurred between reported and modeled head values. Final modeled head residuals (the difference between reported head and modeled head) are all within the error associated with reported head values, well measuring point elevations, or land surface elevations at test point locations. Test point head residuals converged from -17.6 to +12.2 feet; which is acceptable considering the accuracy of test point information and the range of hydrologic uncertainty of the aquifer. The final modeled ground water elevation contours and modeled head values are tabulated in Table 4 and displayed in Figure 3.

Table 4. Test point summary statistics for the calibrated model.

Test Point	Reported Head (ft amsl)	Modeled Head (ft amsl)	Head Residual (feet)
1	5,215	5,215.0	0.0
2	5,209	5,221.2	12.2
3	5,224	5,230.1	6.1
4	5,247	5,244.1	-2.9
5	5,246	5,255.7	9.7
6	5,291	5,282.5	-8.5
7	5,283	5,265.4	-17.6
8	5,302	5,294.6	-7.4
9	5,334	5,329.2	-4.8
10	5,361	5,358.2	-2.8
11	5,398	5,380.6	-17.4
12	5,432	5,434.8	2.8
13	5,453	5,454.9	1.9

Summary Statistics

Number of Observations	13
Most Positive Residual	12.2
Most Negative Residual	-17.6
Average Residual	-2.2
Median Residual	-2.8
Mean Absolute Residual	7.2
Root Mean Squared Residual	9.1

Notes: ft amsl = feet above mean sea level

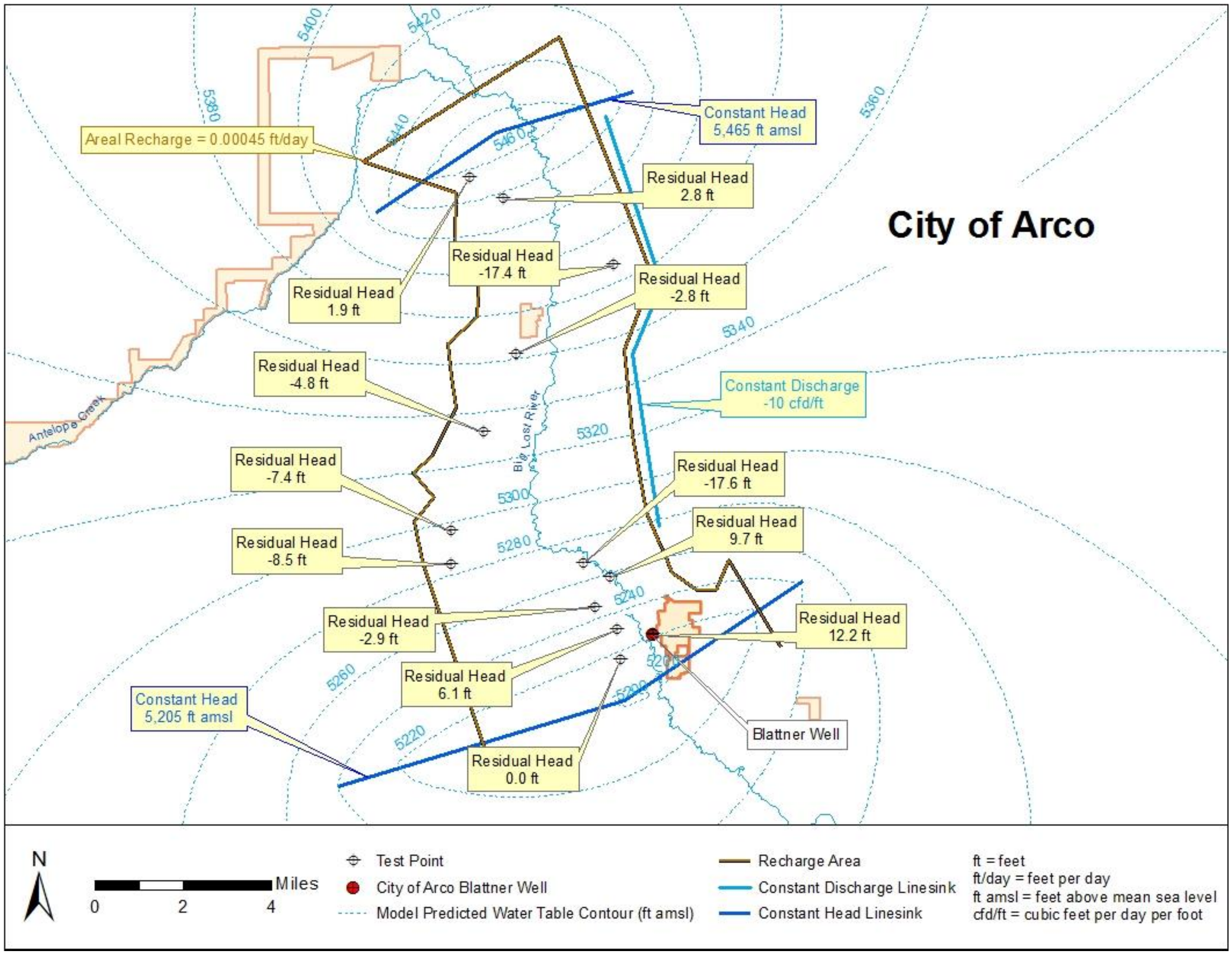

Figure 3. Best fit modeled ground water elevation data at test points.

2.3 Results

In accordance with the Idaho SWAP (DEQ 1999), the final modeled capture zone was given a factor of safety, generally and in this case a +/-10 degree buffer, to account for uncertainty in the modeling effort and to provide a conservative estimate of the capture zone area. As shown in Figure 4, the final capture zone for the City of Arco Blattner well extends to the north –northwest for approximately 3.8 miles and is approximately 1.5 miles wide at its furthest extent.

The capture zone presented in this study is intended as an estimate of the actual conditions based on available data. It should be noted that this capture zone has the potential to be updated or modified as more data become available.

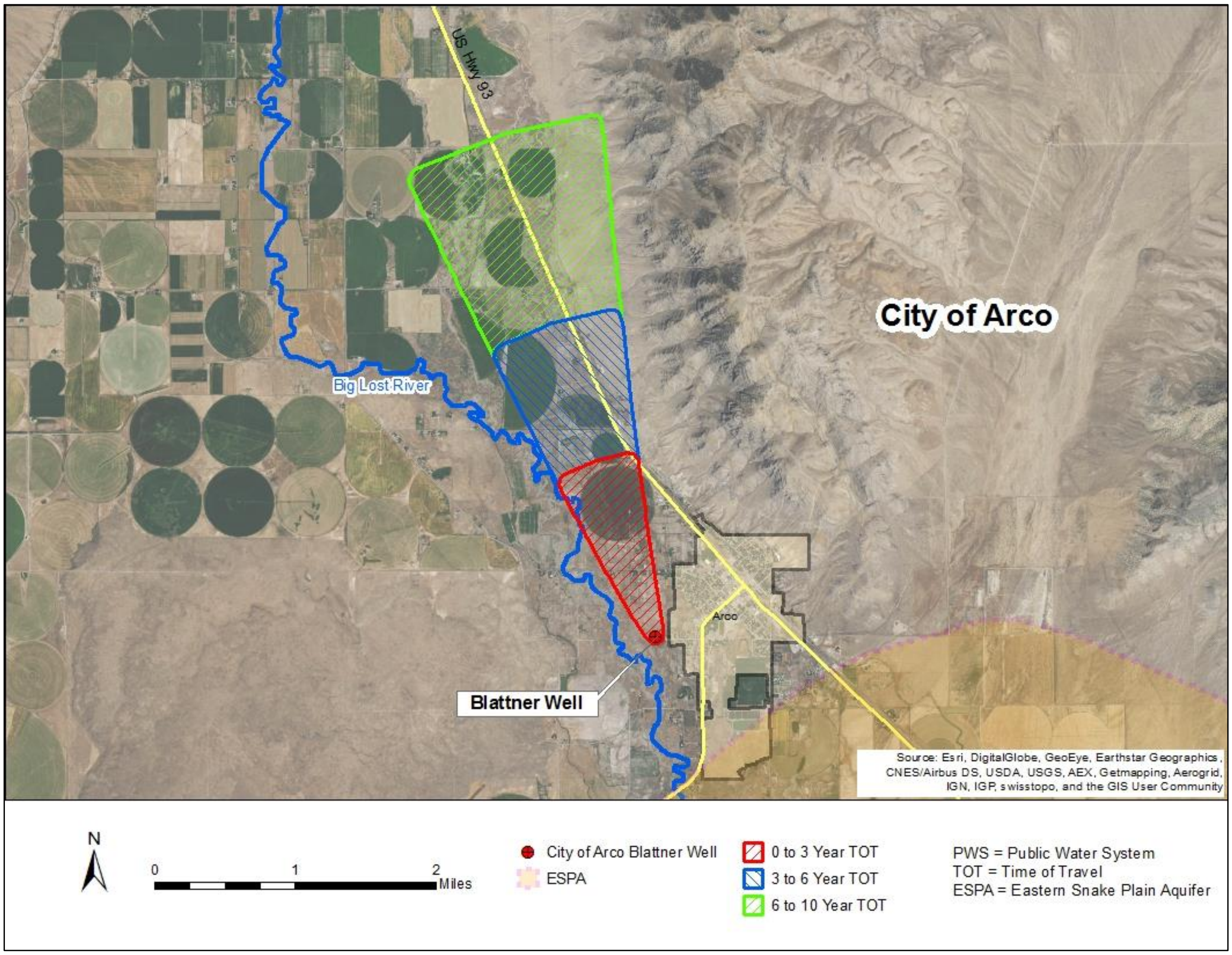

Figure 4. Final capture zone for the City of Arco Blattner well.

2.4 Model Limitations

This SWA model was developed to estimate the capture zone for the City of Arco PWS ID6120001 Blattner well. The capture zone depends on aquifer parameters, recharge rates, and other boundary conditions which vary temporally and spatially. Ground water elevations and other aquifer parameters used in this model are based largely on data described in well drillers' reports, reported water levels, and regional reports. Data in well drillers' reports are general in nature and may not include the detail necessary for a more complete analysis. It is beyond the scope of this project for DEQ to establish or determine variations in boundary conditions. The accuracy and completeness of the resultant aquifer parameters cannot be guaranteed. If additional analysis is desired or the model is considered for another purpose, an independent ground water professional should be retained to conduct additional studies, more detailed model development, or to evaluate alternative application limits of this model.

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Appendix - Well Driller's Report

City of Arco Blattner well

Blattner

Form 238-7
6/07

IDAHO DEPARTMENT OF WATER RESOURCES
WELL DRILLER'S REPORT

BMD

1. WELL TAG NO. D C062453

Drilling Permit No. ____

Water right or injection well # 34-7454 Trans 78637

2. OWNER:

Name City of Arco

Address PO Box 196

City Arco State ID Zip 83213

3. WELL LOCATION:

Twp. 4 North ☒ or South ☐ Rge. 26 East ☒ or West ☐

Sec. 36 ____ 1/4 SW 1/4 NW 1/4

Gov't Lot ____ County Butte

Lat. 43 ° 37.884 (Deg. and Decimal minutes)

Long. 113 ° 18.759 (Deg. and Decimal minutes)

Address of Well Site West end of Blattner Ave. 400' West of canal crossing City Arco

Lot. ____ Blk. ____ Sub. Name ____

4. USE:

☐ Domestic ☒ Municipal ☐ Monitor ☐ Irrigation ☐ Thermal ☐ Injection ☐ Other ____

5. TYPE OF WORK:

☒ New well ☐ Replacement well ☐ Modify existing well ☐ Abandonment ☐ Other ____

6. DRILL METHOD:

☒ Air Rotary ☐ Mud Rotary ☐ Cable ☐ Other ____

7. SEALING PROCEDURES:

Seal material	From (ft)	To (ft)	Quantity (lbs or ft³)	Placement method/procedure
Bentonite	0'	40'	4200 ±	Temporary 20"
Ben Grout	40'	70'	16 ft³	Casing

8. CASING/LINER:

Diameter (nominal)	From (ft)	To (ft)	Gauge/ Schedule	Material	Casing	Liner	Threaded	Welded
16"	+3'	203'	.375	steel	☒	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐

Was drive shoe used? ☐ Y ☐ N Shoe Depth(s) ____

9. PERFORATIONS/SCREENS:

Perforations ☐ Y ☐ N Method ____

Manufactured screen ☒ Y ☐ N Type ____

Method of Installation ____

From (ft)	To (ft)	Slot size	Number/ft	Diameter (nominal)	Material	Gauge or Schedule
203'	239'	.050		14"	stainless	

Length of Headpipe 6' Length of Tailpipe 5' w/ 8" pin

Packer ☒ Y ☐ N Type Triple K

10. FILTER PACK:

Filter Material	From (ft)	To (ft)	Quantity (lbs or ft³)	Placement method

11. FLOWING ARTESIAN:

Flowing Artesian? ☐ Y ☐ N Artesian Pressure (PSIG) ____

Describe control device ____

12. STATIC WATER LEVEL and WELL TESTS:

Depth first water encountered (ft) ____ Static water level (ft) 114'

Water temp. (°F) ____ Bottom hole temp. (°F) ____

Describe access port ____

Well test:

Drawdown (feet)	Discharge or yield (gpm)	Test duration (minutes)

Test method: Pump ☐ Bailer ☐ Air ☐ Flowing artesian ☐

Water quality test or comments: ____

13. LITHOLOGIC LOG and/or repairs or abandonment:

Bore Dia. (in)	From (ft)	To (ft)	Remarks, lithology or description of repairs or abandonment, water temp.	Water Y	Water N
20"	0'	9'	Topsoil		X
	9'	28'	Sand & Gravel		X
	28'	45'	Brown Sandy Clay	X	
	45'	68'	Brown Sandy clay & pea gravel	X	
16"	68'	136'	Brown Sandy Clay	X	
	136'	146'	Brown Clay		X
	146'	148'	Pea gravel & sand	X	
	148'	164'	Brown clay, mudstone		X
	164'	169'	Sand	X	
	169'	184'	Pea gravel, sand	X	
	184'	191'	Very sandy gravel	X	
	191'	196'	Brown Clay		X
	196'	236'	Clean Gravel	X	
	236'	241	Compacted Cemented Gravel		X
	241'	262'	Brown Clay (mudstone)		X
	262'	267'	Brown Clay & Sand & Pea Gravel	X	
	267'	268'	Brown Clay (mudstone)	X	
	268'	278'	~~Black Basalt~~ Mudstone		X
	278'	280'	Black Basalt		X

RECEIVED
SEP 03 2013
Department of Water Resources
Eastern Region

Completed Depth (Measurable): 244'

Date Started: July 23, 2013 Date Completed: Aug. 12, 2013

14. DRILLER'S CERTIFICATION:

I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Company Name Bay Drilling Co. No. 519

*Principal Driller Joey Denning Date ____

*Driller [signature] Date 8/13/13

*Operator II ____ Date ____

Operator I ____ Date ____

* Signature of Principal Driller and rig operator are required.